continued and the service extended as far as possible into the northern rivers, and particularly into the headwaters of mountain streams in the extreme West.

EARTHQUAKE OF MARCH 21, 1905.

By Prof. CHARLES F. MARVIN.

The table below contains the details of the record of an earthquake made on the Omori seismograph at the Weather Bureau, Washington, D. C., at 10 hrs., 59 mins., 32 secs., p. m. (seventy-fifth meridian time) of March 21, 1905.

The record was very clearly defined, and the waves were particularly simple and sinusoidal in character throughout. It appears that the preliminary tremors were of exceedingly long duration, especially as compared with the principal portion of the earthquake. If we had included a series of small waves of regular character which preceded the larger waves actually regarded as making up the principal portion, the duration of the latter might have been made about two minutes longer. However, the smaller waves seemed more properly to belong to the second preliminary tremors.

Earthquake of March 21, 1905, seventy-fifth meridian time.

	h.	m.	s.	
First preliminary tremors began	10	59	32	p. m.
Second preliminary tremors began	11	12	42	p. m.
Principal portion began	11	24	06	p. m.
Principal portion ended	11	26	17	p. m.
End of earthquake (a. m., March 22)	0	13	12	a. m.

Duration of first preliminary tremors	13 min.	12 sec.
Duration of second preliminary tremors	11 "	24 "
Duration of principal portion	2 "	11 "
Whole duration of earthquake 1 hr.	13 "	40 "

Average complete period of 5 long uniform waves, at beginning of second preliminary tremors	30 sec.
Average complete period of 8 uniform waves at end of second preliminary tremors	15.6 "
Average complete period of 7 uniform, strong waves, constituting the principal portion	15.6 "
Period of pendulum	28.0 "
Magnification of record	10 times.
Maximum double amplitude of actual north-south displacement of the earth at seismograph	0.35 mm.

The north and south component of horizontal motion only was recorded.

THE VARIATIONS IN ATMOSPHERIC TRANSPARENCY DURING 1902, 1903, AND 1904.

By HERBERT HARVEY KIMBALL, Librarian and Climatologist, U. S. Weather Bureau.

In the Proceedings of the Third Convention of Weather Bureau Officials, pp. 69–77,[1] are given some results of observations made by me on the quantity of solar radiation received at the surface of the earth, and on the polarization of blue sky light, during 1902, 1903, and 1904. In another column of the current REVIEW Miss R. A. Edwards has given a translation of E. Marchand's account of similar observations covering the same period, supplemented with observations of certain optical phenomena, and made at Pic du Midi and Bagnères, in the Pyrenees, France. A comparison of certain features of these two series of observations is of interest.

In the Pyrenees a diminution in the amount of solar radiation received at the earth's surface was noted at intervals after May 27, 1902. This diminution became permanent in January, 1903, at which time it amounted to 20 per cent of the normal radiation. It reached 50 per cent on the 21st and 22d of the following month, and was quite marked until August of that year, when it amounted to about 10 per cent, after which it gradually diminished, but was noticeable at times up to the end of 1904.

The blueness of the sky suffered a diminution of three units, measured on a scale of 0 to 50.

In my paper above referred to it is stated that—

I was surprised at the small value of the solar radiation received at the surface of the earth during January, February, and March, 1903, but particularly during March.

Also furthermore,

From January, 1903, to March, 1904, inclusive, there was a marked deficiency in the radiation measurements as compared with similar measurements made by Mr. Harvey N. Davis at Providence, R. I., in 1892,[2] amounting in some months to as much as 30 per cent, and in others to less than half this amount.

Since these observations were not all made at one station, they are not strictly comparable; but since Providence, the most northern station, generally gave the largest radiation values, the diminution in radiation as measured in 1903 and 1904 can hardly be attributed to local conditions.

The observations with the Pickering polarimeter, made at Asheville and Black Mountain, N. C., from December, 1902, to March, 1903, inclusive, and at Washington, D. C., from May, 1903, to date, may be compared without considering the discrepancy due to latitude that applies to pyrheliometer observations, although local conditions must also have an effect upon polarimeter observations.

There is a wide variation in the polarization of blue sky light from day to day, even when no clouds are present. I have therefore selected the observations showing the maximum polarization for each month, for comparison in the following table:

Maximum percentage of polarization of blue sky light during each month at a point on the vertical circle passing through the sun, and 90° from the latter.

Month.	1902.	1903.	1904.	1905.	Month.	1902.	1903.	1904.	1905.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
January	.....	51.8	54.1	59.9	July	.....	47.5	61.8	.....
February	.....	53.2	51.6	55.6	August	.....	.....	.....	.....
March	.....	47.4	53.2	61.1	September	.....	54.6	59.7	.....
April	.....	.....	53.0	.....	October	.....	54.6	64.7	.....
May	.....	43.4	54.7	.....	November	.....	57.6	.....	.....
June	.....	37.6	58.9	.....	December	55.7	52.6	62.9	.....

No observations for the months left blank.

Since in general the blueness of the sky and the amount of solar radiation measured at the surface of the earth are proportional to the percentage of polarization of the blue sky light, it is not difficult to trace in the above table the diminution in atmospheric transparency that became marked in the Pyrenees in January, 1903, continued until the following August, and has gradually become less noticeable since that date.

The observations here compared are but two series out of many that show a diminution in the transparency of the atmosphere during 1903, plausibly due to the presence of volcanic dust in the atmosphere. A summary of other observations may be found in my paper in the proceedings of the convention already referred to.

It is a strange coincidence that the observations at the Astrophysical Observatory of the Smithsonian Institution indicate that during 1903 and 1904 not only did the solar radiation suffer unusual absorption in the earth's atmosphere, but the absolute amount received at the outer surface of the earth's atmosphere was less than usual.[3] Naturally the question arises as to the possible relation between these two phenomena. The bolometric observations to be made on Mount Wilson, Cal., during the coming summer, by Professor Langley and Mr. Abbot will no doubt shed much light on this subject.

[1] Variations in insolation and in the polarization of blue sky light during 1903 and 1904. By H. H. Kimball. (Proceedings of the Third Convention of Weather Bureau Officials at Peoria, Ill., September 20, 21, 22, 1904. Washington, 1904.

[2] Observations on solar radiation with the Ångström pyrheliometer, Monthly Weather Review, June, 1903, Vol. XXXI, p. 275.

[3] See Langley, S. P. On a possible variation of the solar radiation and its probable effect on terrestrial temperatures. (Astrophysical Journal, Chicago. Vol. 19. p. 305–321.)

Diminished transparency of the atmosphere for considerable periods is not unusual. The meteorological conditions are frequently such that during an entire month there will not be a single day with a clear sky. But where such a variety of observations show a turbid condition of the atmosphere for several successive months, and even on days when meteorological conditions are favorable for a clear sky, some other explanation is necessary. In the case under consideration this is supplied, as indicated by Marchand, by the great quantities of volcanic dust thrown out by the eruptions in the West Indies during May, 1902.

TWILIGHT GLOWS AND CONNECTED PHENOMENA OBSERVED IN 1902, 1903, AND 1904 IN THE PYRENEES.

By E. MARCHAND.

[Translated by Miss R. A. Edwards, from the Annuaire de la Société Météorologique de France, February 1905, p. 40-45.]

I will summarize here, very briefly, the observations made on these phenomena at Pic du Midi or at Bagnères, by my coworkers, Messrs. Ginet, Latreille, Dort, and myself, since the end of the year 1902; observations which have been communicated at different times to the Société Ramond, principally in the meetings of February 3, and April 7 and 12, 1904.

Three principal phenomena have been distinguished which can be attributed, nevertheless, to the same general cause, the presence of dust, or perhaps of extremely fine particles of ice, in the upper regions of the atmosphere, the dust coming probably from the great eruptions of the volcanoes of the Antilles in May, 1902. These three principal phenomena are: (*a*) twilight glows; (*b*) solar or lunar coronas; (*c*) diminution of solar radiation. And we shall have occasion to mention several others of less importance.

(*a*.) TWILIGHT GLOWS.

Two phases of this phenomenon may be distinguished; (1) The appearance, fifteen or sixteen minutes after sunset[1] of a first twilight segment, pink, purplish, or copper red, which lasts from twenty to twenty-five minutes and then disappears below the horizon, leaving but a more or less persistent band of red or orange. The phenomena are naturally reversed when one observes in the morning before sunrise. (2) The appearance, about fifteen minutes after the disappearance of the first segment, of a second segment, pink or copper red, occupying about the same position, and disappearing in the same manner, but remaining sometimes much longer than the first.

The first segment is not peculiar to the period 1902-1904, during which time it only became much more intense and much more brightly colored. It exists at all times but it was on July 31, 1902, that I found it for the first time at Pic du Midi of an abnormal intensity; an intensity which I observed afterwards at various dates, during August, September, and October; but it was not until the end of October that it attracted the attention of the public.

By observing carefully the angular maximum height of the summit of this colored segment (due to the reflection of the solar rays, tangential to the earth, on the dust of the upper atmosphere) and the corresponding hour, one may calculate the height of the dust above sea level; allowing for refraction, these calculations have given me rather variable numbers, comprised between 10 and 40 kilometers.

The second segment, also, usually exists; but it consists ordinarily of a faint white light and therefore generally passes unnoticed; since the month of October, 1902, it has frequently been of a pinkish tint or copper red, sometimes brilliant and contrasting strikingly with the rest of the sky, which, at this time is very dark.

[1] We have reference here to the astronomical sunset, which may differ somewhat from the real sunset. At Pic du Midi, the real sunset takes place from eight to thirteen minutes after the astronomical sunset, on account of the large depression, 1° 42′, of the sensible horizon.

It is this second segment, when it is colored, that constitutes always, for the public, the twilight glow; it is produced by the solar rays that undergo two reflections on the atmospheric dust.[2]

In other words, one may say that the sun itself is the source of light of the first segment, although it has already set at the place where one observes this segment; while the source of light of the second segment is the colored region of the first segment or horizontal band, which latter is in the horizon of that elevated point in the atmosphere where this second segment is produced.

After August, 1902, the first segment, with its brilliant coloring, was observed several times each month; the second segment was relatively rare and was produced only during groups of two, three, and four days, separated from each other by rather long intervals, sometimes of several months. We must conclude from this that the atmosphere has probably contained a large quantity of dust at a high elevation ever since the latter part of the year 1902, but that it was probably not always abundant enough or elevated enough to be able to produce the second segment.

However, the second phenomenon demands not only the presence of very elevated dust; it is also necessary that the atmosphere be clear to a great distance from the place of observation to the east, for the morning, or to the west, for the evening. This can not occur frequently; therefore, contrary to what certain authors think, the absence of this second segment does not prove the absence of atmospheric dust.

Moreover, other related phenomena, which I will briefly enumerate, go to prove, in their turn, that this abnormal dust has never been absent during two years.

(*b*.) SOLAR AND LUNAR CORONAS—ANTHELIA.

After examining carefully the notes that accompany our observations with the dynamic actinometer and which give exactly the condition of the sky about the sun,[3] I find that the solar corona was clearly perceived for the first time at Bagnères and at Pic du Midi, July 26, 1902, that is, about two months and a half after the great eruptions at Martinique. But it was only beginning with the month of December of the same year that it was seen permanently around the sun, or around the moon during the night. It is still visible whenever the sun shows itself; however, it seemed less luminous in 1904 than during 1903.[4]

This corona is composed of a sort of circular white halo, immediately surrounding the sun, and whose exterior contour is slightly tinted with copper red or purplish pink. The coloration can be seen only by hiding the sun behind an obstacle somewhat distant from the eye, such as a tree, the summit of a house, etc.

The mean diameter of the colored ring, as measured very frequently at Bagnères or at Pic du Midi,[5] was about 48°, varying from 46° to 50°, at the end of 1903; the width of this ring was at that time about 20°; the outer diameter of the corona was about 70°. At the present time the mean diameter appears to be from 40° to 44°; the measurement is difficult, however, especially at the present time, because the colored ring merges insensibly into the white halo of the interior, and into the blue sky of the exterior.

At the close of 1903, we frequently saw in the luminous halo

[2] I wish to state, in the beginning, that I describe always the phenomena visible in the evening; that the words first and second segment relate to the sunset; and that in the morning these phenomena occur in inverse order.

[3] At Bagnères and at Pic du Midi, we take observations every three hours, daily, with a static actinometer and besides, when the state of the sky will permit, with a dynamic actinometer (of a system intermediate between those of Violle and of Crova).

[4] The name Bishop's ring is often given to this corona.

[5] For these measurements and for all those that may have to be made on the phenomena of atmospheric optics, I have devised a special graphometer, very easily used, very convenient, and very easy to construct.